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SAFETY AND SERVICE DIFFICULTY REPORTING

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Today, safety is considered to be of highest importance in most societies. In the context of the military, safety is essential to averting loss of life and damage to a high-value asset. While safety may take second place to winning a war, its importance is further accentuated because of its connotation to battlefield readiness. There have been numerous instances to illustrate this last point. To wit:

- Widespread Fatigue Damage (WFD) was discovered in "weep holes" of fuel tanks of some C-141 military transport airplanes. Because of the loss of minimum residual strength, with the attendant risk of catastrophic fracture posed by WFD, the entire fleet had to be grounded and an expensive refurbishment program had to be undertaken before the fleet was deemed to be airworthy. In this instance, the unsafe condition was detected and corrected quickly, so no lives were lost nor did any of the airplanes in the fleet suffer catastrophic damage. However, the grounded aircraft were certainly not battle-ready for a certain length of time. Had they been sent into battle, they would have had to be operated under severe flight restrictions and, thus, their utility to serve the purpose of the deployed forces would have been very restricted. Had they been deployed without any restrictions, in all probability they would have been unable to complete their missions and the Air Force could have lost valuable aircraft assets. Also, the necessary logistic support to properly carry out tactical operations in the battlefield would not have been available.

- WFD was the primary cause of a highly publicized air accident involving a commercial aircraft. The wide publicity given to that single accident, abetted by on-site video tape recording of the condition of the aircraft after it had landed, shook the confidence of the public in the safety of commercial aviation. As a result, inspection and refurbishment of 3000 jet transport airplanes among a fleet of about 5000 was mandated by the authorities, to be undertaken on an urgent basis. The economic impact of this mandate on the airlines, the aircraft manufacturer and the flying public was high and resulted in numerous complaints to the regulatory authorities. It must be noted that since that time more than twelve years have elapsed without a single accident attributable to WFD.

These instances explain my motivation for including the subject of safety during this Lecture Series. However, the subject is extensive and so many books have appeared that address some aspect or the other that my remarks are meant to complement the existing literature. Much of what I intend to share with you today is not something I have developed on my own, rather it has been influenced by my comrades and peers when I was in the civil aviation community.

Scope of the Lecture - Analysis and Data Requirements for Assessment of Operational Safety:

An aircraft is an assemblage of complex and highly integrated sub-systems - the structure, the power-plant, the electrical, the mechanical, and hydraulic systems, the avionics suite, the human-in-the-loop to name a few. To eliminate the risk of the sub-systems to fail, individually or in concert, safety analyses are routinely performed by aircraft manufacturers. The manufacturer also conducts analyses to ascertain the consequence of a failed part to assure that it does not in any way threaten the safety of the entire system.

Before an aircraft model enters service, whether for military or civil use, the design has to satisfy a rigorous set of requirements, which are governed by regulations. These requirements include an analysis of the probability of failure of each component and the hazard caused by the failure. This subject, termed as "Systemic Safety [1]," will be beyond the scope of this lecture. Rather, the remarks will concentrate on the operational phase of the aircraft's life. That is the phase subsequent to the aircraft put into operational use for the first time.

However, keep in mind that before the aircraft enters the fleet, there are numerous design reviews, ground and flight tests, and production approvals that are required to assure that the aircraft is safe and able to perform as intended in the operating environment. At times, the origin of problems that are encountered in service may be inherent in the design or the manufacturing stage or due to construction methods. For instance, an element in the chain that led to the failure of the commercial aircraft mentioned earlier was a failed bond. The failed bond resulted from an inadequate bonding process. It created stress risers at the rivets, which were designed to merely serve as secondary conduits for transferring load. The resulting fatigue cracks were aggravated by loss of material due to corrosion, resulting in intrusion of moisture from condensation and precipitation. Such problems that are encountered in service must be quickly corrected in order to prevent accidents and to maintain battle-readiness of the fleet. An essential requirement for quick resolution of these type of

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problems is a technical team that is familiar with not only the design features of the aircraft model and any subsequent modifications that had been effected previously but also the original design philosophy that guided the design. Often, it is beneficial to retain some members of the original design team to serve in the maintenance group in order to maintain the necessary know-how.

Measurement of Safety

In order to assess safety of a system after it enters service one must define safety and establish a set of metrics (measurement standards) for safety. A metric may be the number of failures per one thousand operations, or it may be an incident rate or an accident rate. Such gross metrics are normally refined by dividing the accidents into categories by causal relationships. Furthermore, metrics are often normalized in terms of usage. In any event, the establishment of safety metrics has been subjective, to say the least, and a bit disorganized from the standpoint of relating the accident cause, the events leading up to the accident, and the design fix. The problem is best illustrated through Figure 1, and 2. Both figures have been extracted from publicly released Boeing Airplane Company documents [2, 3]. They depict the relative risk of an accident as a function of the phase of flight, based on historical data. Clearly, if miles flown is chosen as the normalizing factor for a safety metric, the metric chosen ignores the fact that risks between destinations involving multiple flight legs and the risk involved for a single leg, for the same distance traveled, are unequal - hence, the metric would be inappropriate. Similarly, in the assessment of military aircraft, the hours of operation is usually chosen as the normalizing factor but such a choice ignores the fact that the mission profiles could be vastly different, even for the same aircraft model but used in different squadrons. Thus, the establishment of multiple metrics for risk using the same database increases the opportunity for establishing a correlation between data and risk, thereby making the safety management system more robust.

Accidents and the Role of Precursors:

It is generally agreed that there exist certain precursors to each accident and incident. If one of these precursors is not recognized and the underlying condition that has caused it is not corrected in time, then it can graduate into an incident or even an accident. Aircraft are highly engineered systems, endowed with redundancies and fail-safe features. They are "noisy" systems. That is, they can give so many indications, of which only a few are precursors, that one can easily be lulled into complacency. Fail safety embraces two concepts. One is the concept that the first failure does not impair functionality of the system. The second is that the first failure must be obvious to the extent that it will, in all likelihood, be detected well before the onset of subsequent failures, which may endanger the safety of the system. Thus, the first occurrence of a service difficulty associated with a sub-system in an aircraft is a prospective precursor of progressive failures that could result in an incident or accident. Furthermore, multiple occurrences of service difficulties, especially after corrective actions have been attempted, are indicators that the risk of an incident or accident is rising. To take full advantage of being given such warnings, the organization responsible for safe operation of the aircraft must systematically collect reports of service difficulties. Just as importantly, this same organization must systematically and expeditiously analyze the reports being collected to establish their root cause of the difficulty or difficulties and its potential for a resulting accident or incident. The analysis must be accomplished early in order to allow sufficient lead-time for corrective action to be taken. Even with a service difficulty collection and analysis system in place, the organization will be unable to use it to reduce or eliminate incidents and accidents unless higher management in the organization recognizes their value and directs development and implementation of corrective action. Clearly, improved safety will result if attention is more focused on precursors.

Detection of Service Difficulty

A Service Difficulty is symptomatically manifested by one of the following:

Visual, such as cracks, warning lights, observation of smoke, etc.

Aural, such as alarms, abnormal sounds, etc.

Tactile, such as excessive vibration, electrical shock, stick response, etc.

Olfactory, such as fumes from electrical systems or oil or rubber, etc.

Response to transducer devices such as those used for nondestructive inspection of structural components.

Service difficulties can manifest themselves during airworthiness inspections and other maintenance related activities. One example is the detection of a structural fatigue crack in an area adjacent to the area being inspected. The maintenance program had no instructions for inspecting this cracked area. Had the service difficulty report not been filed on this crack, and had a single observant authority representative not discovered this difficulty report and investigated it, further crack growth in this area and other aircraft might have occurred and graduated into something serious.

It would be erroneous, however, to draw a correlation between the number of service difficulty reports generated and risk. A large number of reports may mean that the operational and maintenance personnel are alert and diligent in reporting discrepancies, not necessarily that the risk of failure is rising. In this case, it may

simply be a tribute to the robustness of the inspection and maintenance program. Only systematic analysis performed by trained and knowledgeable analysts can correlate the risk level to the number of service difficulty reporting rates.

Analysis and Data Requirements

There is a symbiotic relationship between: (a) the purpose of safety analysis, (b) the methodology to be used for evaluating safety (or risk), (c) the data required to perform safety analysis, (d) the confidence to be reposed in the results, (e) and the burden of the data collection effort. All five aspects will have to be considered in concert to devise a robust system that balances system costs (figure 3).

Safety analysis may be required for a variety of purposes. For instance, to gage the general health or safety of the fleet would require a different methodology and could be accomplished with an abbreviated set of data elements than what might be needed for a forensic analysis of an accident or incident. Thus, the circulation of a questionnaire among the various groups involved in maintaining safety to establish the connections between analysis methodologies that are being used or desired, and the respective data requirements is advocated.

Aircraft systems are becoming more and more complex, placing more sophisticated demands on data collection and analysis methods. Also, the increased attention being given to safety and the accompanying demand for data driven safety programs, makes the data elements that would have been considered adequate in the past appear as lacking in precision and detail. Thus, the number of data elements, the extent of detail to be included in any gathering effort, and the configuration of the database itself should be designed to allow for some growth in data requirements. It is imperative that an organization designing a service difficulty reporting system that mandates the collection of certain data elements simultaneously considers the analysis to be conducted of the collected data. Many existing databases, such as the Service Difficulty Reports being maintained by the Federal Aviation Administration have come in for criticism [4]. These databases collect many pieces of data that are not used or are redundant. Such databases are primarily designed to facilitate the collection of data but with little or no attention being paid to the needs of the analyst to correlate the data with the airworthiness of the individual aircraft or the fleet. Hence, it is advocated that a safety program - any safety program - be revisited, perhaps re-tuned, every five years, both from the viewpoint of currency and adequacy.

Avionics-related malfunctions may have serious implications in terms of safety of new generation aircraft. These systems are being given more authority over primary flight control of the aircraft. Thus, the reporting of associated malfunctions, defects, and failures become more critical to proactive safety analysis. Their failures during any phase of operation may have safety implications. In any event, data should be collected to support explicit program requirements. Terminology such as "abnormal or emergency actions" and "endanger the safe operation" in regulations will not provide consistent reporting without further definition and guidance.

The distinction between reliability and safety is much debated in the context of data requirements. It has been argued the data needed for performing safety analysis is not as extensive as that for maintaining reliability. However, with the emergence of the nearly synonymous philosophies of Reliability-Based Maintenance and Condition-Based Maintenance, which takes the risk of failure(s) into account, the distinction is blurring.

Hand-held electronic devices have eliminated much of the paperwork in data gathering. Such devices make possible the gathering of voluminous data without making the data gathering effort either burdensome or time consuming. In fact, the development of software that can readily depict on a hand-held device the geometrical layout of components as well as the inter-connectivity of the functional units would make facilitate acquisition of data that capture more details about a malfunction or a failure than is now the case. Electronic entry of data has another great advantage, viz., it avoids data corruption due to transcription errors and expedites the addition of more data elements to the database.

Data Standards

The term "data quality" can at once mean different things, such as erroneous data, inconsistencies in the data, insufficient detail that has been captured in the data, completeness of the data sets, etc. Each of the meanings has a bearing on safety. For instance, there is a wealth of data about instances of cracking in airframe structures but they are not very useful because of lack of precision and standardization. From the standpoint of systematic analysis of large quantities of data, the most important attribute of a safety related database is consistent reporting. The adoption of a common terminology is one aspect of consistency. Clarity of terminology is a related aspect. A critical need for data that is stored in relational databases is that fields should be assigned in each data record (report) to allow for supplementary comments by the mechanic. The FAA maintains one of the largest safety database in the world, the Service Difficulty Reporting (SDR) System. However, because the SDR is a relational database, no provision has been made for supplementary notes. For instance, the database does not allow the mechanic to record the specific location of a crack, even if one is found in a principal structural element. As a result, many users rely on the SDR system only to confirm critical problems that have already been found or suspected - not to give precursory evidence of potential incidents or accidents.

Table 1 exemplifies a form for data recording, which would make possible supplementary notes to be made by the mechanic or inspector. The form for reporting incidents was devised by an internal FAA team, of which the author was a member. The data requirements for reporting service difficulty can be developed in an analogous fashion.

In the military context, harmonization of data standards with our NATO allies will inevitably result in more robust safety systems for all concerned. Also, since the occurrences of many types of malfunctions are rare, harmonization will allow data to be shared between nations that operate similar aircraft systems and increase the data pool, thereby decreasing uncertainty inherent in statistics-based analysis schemes.

Completeness of data, whether the entry relates to deviation, malfunction, or wear is nearly as important. The need to report and record every deviation from the norm, even though the vast majority of cases are benign, cannot be over-emphasized. It is also essential for the analyst (or analysis group) to promptly acknowledge receipt of each report and, once the analysis of a report is complete, to communicate the results to the maintenance group. Otherwise, the latter group may lose faith in the system.

Data Archival and Retrieval

An efficient database storage system has to take into account several factors. Simultaneous access to multiple users may be one requirement. Inclusion of pictures, and documents in the database may be another. There are several ways to store and present data and several types of database management systems (DBMS) have been devised and are commercially available. In choosing the right type of DBMS it is important to consider the capability of a typical user and the purpose underlying the use of the data. For safety analyses purposes, the DBMS should be capable of storing and manipulating complex objects and data types efficiently. The most suitable type and currently available DBMS are the ones known as object-oriented DBMS. Such relational databases allow for computer-aided searches and sorts that are simple to implement , allowing the user to concentrate on deriving the information he or she is seeking rather than focusing on the design of the database extraction tool. On the other hand, if one is willing to invest in more complex search engines, the database may need to be less structured and therefore contain much more information. An explanation of the various types of DBMS can be found in reference [5]. Even object-oriented DBMS have their drawbacks and, thus, the entire subject deserves research attention.

Analysis Methods

Service difficulty data can be used for a variety of purposes and in a variety of ways. The common thread that runs through all of them, however, is risk mitigation. Obviously, the criticality of the component associated with the data, the number of incidences of failure, the consequences of failure, the method(s) used for analysis, the confidence band inherent in the analysis results, and the statistical character of the occurrence are inextricably related.

Accidents and, to a lesser extent, incidents and malfunctions typically involve a chain of events. The chain may simultaneously involve a design deficiency, a defect induced during the manufacturing process, improper maintenance or other human factors. Some aspects that are frequently involved are given in Table 2.

It has been argued that, since many factors are involved in causing an incident or accident, the safety management system should be highly centralized. The author would argue in favor of the opposite, mainly because the safety system would be redundant and, hence, more robust. The responsibility for safety should be divided into sub-groups, whose prime responsibilities are related to maintenance or air traffic control or some other factor identified in the table. Each group should be persuaded to believe that they are ultimately responsible for safety and each group should be allowed to devise their own system for monitoring risk. Of course, each such group will be much better versed in their own specialty and might tend to give greater attention to it. On the other hand, it can be argued that they will tend to take less for granted in other specialty areas and therefore subject them to greater scrutiny.

If the aforementioned view is accepted, it would follow that each group will have different data requirements. The latter can be fulfilled with relative ease by customizing data, but which is drawn from the same master data pool.

One example of an extensive and well-disciplined service difficulty reporting and collection system, as has been previously mentioned, is that being maintained by the FAA. Unfortunately, the FAA does not have the means to systematically analyze the data reported, which purportedly is not all-inclusive. Instead, it does so in an ad-hoc manner. That is, it researches the database to seek service difficulties that indicate the pervasiveness of a fault in the aircraft fleet. Such searches are carried out after the problem has been brought to the attention of the authority through other means, such as an incident or an accident. However, the efforts of the FAA are a valuable adjunct to the safety analysis efforts by industry. Moreover, the SDR database is accessible to other users, such as aircraft manufacturers and operators, who, because of their focus tend to be more systematic in the analysis of the data.

Causal Analysis

Causal analysis of an accident or incident seeks to establish those factors that were judged to be directly responsible in causing the event (primary causal factors) and those that contributed to the event (secondary causal

factors) by deconstructing the accident. For these causal factors, a causal chain can usually be established for each accident or incident [6]. The advantage of causal chain analysis is that in the case of multiple causes and multiple accidents or incidents, the common events or elements in the chain can be identified and subjected to greatest attention. Thus, the safety system can concentrate on those common events and maximize its responsiveness and effectiveness in for cutting down-times, and reducing or eliminating accidents. The perceived disadvantage of this approach is that it is reactive rather than proactive. That is, the regulating authority and the industry (or the military operators) seek to eliminate the causal factor after the accident in order to prevent accidents due to the same cause from happening again.

Causal analysis does have an advantage over simulation and technical conjecture in that it is based on factual data rather than models that mimic a hypothetical event or engineering judgement, which relies on the knowledge base and experience of the technical team. Moreover, as has already been mentioned, in today's aviation industry, it is difficult to retain an engineering team that is intimately familiar with the continuous changes in the aircraft design after production begins.

The causal analysis approach, however, also suffers from the disadvantage that the analysis has a good measure of subjectivity, both in regard to the list of factors and their relative contributions. Also, due to the inter-dependencies of the various factors, such as those listed in Table 2, that are frequently encountered, the relative weights ascribed to the various causal factors can vary a great deal, as a function of the analyst. Thus, an intimate knowledge of the aircraft system is a prerequisite for someone engaging in causal analysis. The challenge of managing aircraft safety is identify and focus on truly hazardous conditions, so they can be eliminated before a potential accident becomes a reality.

Trend Analysis

One simple and effective method is used in the Aviation Safety for Accident Prevention (ASAP) program that is used by the FAA's Rotorcraft Directorate in Ft. Worth, Texas. The program selects components that fail by part numbers. For each part, it reviews the service history for 3, 6, 12 or 24 months periods. Based on the counts of service difficulty reports involving the part number, it predicts trends.

A risk level is assigned to each report. ASAP has the ability to quickly research whether an accident had a service difficulty history. For example, responding to a fatal accident involving the tail rotor driveshaft, the analyst was able to track part numbers, and identify five service difficulty reports that had found the part to have been worn beyond limits, and contained cracks or corrosion. Two of the reports described the results of inspection to be a sheared tail rotor driveshaft. Based on the accident and the supporting trend indicated by the service history, the Authority issued an Airworthiness Directive (AD). A year after the issuance of the AD there were no more service difficulty reports, citing that particular part was reported. But, more importantly, the incidence of sheared rotor drive shafts has been drastically reduced. However, ASAP has one drawback: usage of ASAP is not yet proactive in that the analyst must be prompted by an event, such as an accident or incident to conduct trend analysis on a given part or component.

Monitoring of Safety Through Performance Indicators

The FAA's Flight Standards Service has developed a heuristic-based system called Safety Performance Analysis System (SPAS), primarily for the benefit of their corps of safety inspectors. They started building the system by getting teams of highly experienced and proficient inspectors together, with each inspector identifying the parameters that he or she uses during surveillance of an operator or a repair station facility. Each team discussed each of the identified parameters and developed a consensus about the relative importance of the parameters that must be scrutinized. Next, the parameters were weighted according to their perceived importance and aggregated into groups, with each group being termed as an "indicator." The advantage of a system that is based on indicators is that pools the knowledge and experience of the "gray beards" or the more experienced inspectors in the regulating Authority for use by the younger, less-experienced inspectors. Hence, it focuses attention on what is a warning rather than on events that are merely "noises." The disadvantage is that a rational derivation of threshold values, which signal caution or even danger, is not possible.

A variation of the idea of performance indicators as measures of safety is proposed by the author. It is based on "wiring diagrams" of sub-systems being used in conjunction with the concept of indicators. In the pristine condition, every cell in the wiring diagram would be colored white. When a failure of a certain part occurs, the analyst assesses the criticality of the part to flight safety and assigns a hue to that part (cell) in the wiring diagram. A deeper hue or color would signify that the part has a relatively high criticality. The wiring diagram is constantly updated by adding more color to the particular part to reflect arrival of new service difficulty reports. Two events will attract the attention of the analyst. The first is the depth of the hue of a certain cell and the second is the contiguity of cells (the ones that are sequentially tied or represent the redundant feature), in terms of their function, that are hued. The idea is based on the recognition of the fact that in both cases the risk of sub-system failure is increasing, and that the wiring diagram pictorially represents the rise. In fact, it would be relatively easy to convert the logic into a computer code that automatically raises a flag in either case, which cannot escape the attention of the analyst. Also, different colored flags may be set up to indicate

the level of alert. The scheme will also need to take into account replacement or re-design of the part, or the sub-assembly itself. That is also easily done by washing out the color in the particular cell representing the part or in the block of cells if the sub-assembly has been redesigned or refurbished

Probabilistic Risk Analysis

Several probabilistic approaches to safety have been proposed {7}. However, such approaches are not looked upon with enthusiasm because no one wants to look upon safety management in a manner that resembles a game of chance. However, there are at least two major advantages of a probabilistic approach. First, it takes into account the variability in the data as well as the trends in the number of occurrences. It also provides for considering the relationship between seemingly unrelated occurrences. The analyst must examine the estimated probability of an accident, given a high probability of the occurrence of service events, and determine if intervention is required. A unique advantage of the probabilistic approach over a deterministic approach is that it enables the Authority or the SafetyOffice in the military to focus on the most likely causes of hypothetical, future accidents, and prevent them. By far the most important advantage is that it enables the Authority, and the operators, to get ahead of the power curve - that is, to correct the condition before the first accident occurs.

Concluding Remarks

As new technology is inducted, aircraft systems will inevitably become more complex. New technology generally means better performance and lower costs but there might be safety-related challenges as well. Also, increased usage and operating missions beyond what was envisaged in the design stage will magnify the accident rate as well as the fatalities, injuries, or losses of high-value assets. Safety systems will need to be more sophisticated and better methods of analysis will need to be employed. Authorities, and in the case of the military - themselves, will need to focus more on preventing accidents due to service related events rather than using service data to confirm the analysis of accidents that have already happened. Concomitantly, more extensive data require-ments and data archival systems will need to be engineered. Thus, the cost of maintaining a high level of safety is bound to rise but the cost due to not having an effective system will be many times greater. Safety of highly engineered systems, like aircraft, has a high price tag but the alternative will prove to be much, much more expensive.

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TABLE 1: EXAMPLE OF A FORM FOR RECORDING AN INCIDENT

BATCH # ______________________ I.D. # ______________________

REV.	DATE	ANALYST	REVIEWER
0	___/___/___	____________	____________
1	___/___/___	____________	____________
2	___/___/___	____________	____________
3	___/___/___	____________	____________

EVENT ID NUMBER:
___/___/___/____
YY MM DD SE

TIME OF EVENT: (SELECT ONE)
UNKNOWN ________
UT ________
LOCAL TIME ________

EVENT CLASSIFICATION:
HAZARDOUS ____________
MAJOR ____________
MINOR ____________
DAMAGE ____________

LOCATION:
DEPARTURE AIRPORT ____________
DESTINATION AIRPORT ____________
EVENT LOC. (CITY) ____________
COUNTRY (EVENT) ____________
LAT/LONG ____________
UNKNOWN ____________

AIRCRAFT:
TYPE-SERIES ____________
A/C MAKE ____________
FUSELAGE NO. ____________
DATE MANUFACTURED ________
TAIL NUMBER ____________
SERIAL NUMBER ____________
ENGINE MAKE ____________
ENGINE MODEL(S) ____________
ENGINE SERIAL NO(S). ________
FLIGHT NUMBER ____________

TYPE OF MISSION: (SELECT UP TO 2)

SCHEDULED PAX	CARGO
UNSCHEDULED PAX	FERRY
FLIGHT TEST	TRAINING
UNKNOWN	
MAINT	

AIRLINE/OPERATOR:
OPERATOR NAME ____________
OPERATOR OAG CODE ____________

METEOROLOGICAL/ENVIRONMENT CONDITIONS:

IMC/VMC ____________	VERTICAL TURBULENCE ____________
CLOUD CEILING FT OR M ______	HAZE ____________
LIGHT CONDITIONS	HAIL ____________
DAY/NIGHT/DUSK/DAWN ______	BIRDS ____________
VISIBILITY FT, M, MI ________	SNOW/SLUSH ____________
WIND: DIRECTION ________	SAND/ASH ____________
VELOCITY IN KTS ________	THUN STRMS ____________
TEMPERATURE F OR C ______	LIGHTNING ____________
MICROBURST ____________	OTHER WEATHER ____________
CAT ____________	ICE/RAIN/FOG/GUSTS ____________
WINDSHEAR ____________	

PHASE OF OPERATION

BOARDING	DESCENT	DEBOARDING
CARGO LOADING	APPROACH	PARKED
ENGINE START	INITIAL	REFUELING
TAXI	FINAL	INSPECTION
TAKE OFF	LANDING	TOWED
ROLL	FLARE & TOUCHDOWN	SERVICING
ROTATION	ROLL	UNKNOWN
INIT CLIMB	TOUCH AND GO	CLIMB TO CRUIS
GO AROUND	CRUISE	TAXI
DURING DIVERT		

HARDWARE INVOLVED IN INCIDENT:		
		ATA CODE ___/___/___
		NAME ______________
________	________	MODEL ______________
________	________	MAKE ______________
________	________	LOCATION______________
________	________	PART NUMBER______________
________	________	TOTAL TIME______________
		TIME SINCE O/H______________
		CYCLES SINCE O/H______________
		TOTAL CYCLES______________

TYPE OF HUMAN MACHINE INTERFACE ERROR
Suggest that a coded list be developed that is similar to ATA codes

NAT. AVIATION SYSTEM (NAS): TBD

FLIGHT CREW EXPERIENCE:

CAPTAIN ______________	PILOT IN COMMAND ______________
TIME IN TYPE ACFT ________	TOTAL FLYING TIME ______________
FIRST OFFICER	
TIME IN TYPE ACFT ________	TOTAL FLYING TIME ______________
SECOND OFFICER	
TIME IN TYPE ACFT ________	TOTAL FLYING TIME ______________

DATA SOURCES:

FLIGHT CREW______________	ATC______________
MAINTENANCE______________	CAA ______________
OPERATOR______________	FLT INT ______________
MANUFACTURER______________	FLIGHT SAFETY FOUNDATION______________
NTSB______________	NEWS______________
WAAS______________	AIRCLAIMS ______________
	OTHER______________

BRIEF DESCRIPTION: ______________________________

Describe the event/situation. Keeping in mind the following topics, discuss those which you feel are relevant and anything else you think is important. Include what you believe really caused the problem, and what can be done to prevent a recurrence, or correct the situation. (USE ADDITIONAL PAGES IF NECESSARY)

1. CHAIN OF EVENTS
   - How the problem arose
   - Contributing factors
   - How was it discovered
   - Corrective actions taken
   - System configurations and operating modes
   - What procedures were used
   - How did you decide what to do
   - What stopped the incident from becoming an accident
   - Failure in Cockpit Resource Management Fatigue

2. HUMAN PERFORMANCE CONSIDERATIONS
   - Perceptions, judgements, decisions
   - Factors affecting the quality of human performance
   - Actions or inactions
   - Lack of positional awareness
   - Lack of awareness of circumstances of flight
   - Incorrect selection on instrument/navaid
   - Action on wrong control/instrument
   - Slow/delayed action
   - Omission of action/inappropriate action
   - Fatigue
   - State of mind
   - Lack of qualification/training/experience
   - Incapacitation/medical or other factors reducing crew performance
   - Deliberate non-adherence to procedures

FULL NARRATIVE: ______________________________

ANALYST COMMENTS: ______________________________

Factors Relevant to Incident
(Each incident usually has more than one factor)

Group	Factor	No. acc.
A. *Causal factors*		
A.1 Aircraft systems	1.1 System failure – affecting controllability 1.2 System failure – flight deck information 1.3 System failure - other	
A.2 ATC/Ground aids	2.1 Incorrect or inadequate instruction/advice 2.2 Misunderstood/missed communication 2.3 Failure to provide separation - air 2.4 Failure to provide separation - ground 2.5 Ground aid malfunction or unavailability	
A.3 Environmental	3.1 Structural overload 3.2 Wind shear/upset/turbulence 3.3 Icing 3.4 Wake turbulence - aircraft spacing 3.5 Volcanic ash/sand/precipitation etc. 3.6 Birds 3.7 Lightning 3.8 Runway condition unknown to crew	
A.4 Crew	4.1 Lack of positional awareness - in air 4.2 Lack of positional awareness - on ground 4.3 Lack of awareness of circumstances in flight 4.4 Incorrect selection on instrument/navaid 4.5 Action on wrong control/instrument 4.6 Slow/delayed action 4.7 Omission of action/inappropriate action 4.8 "Press-on-Us" 4.-9 Failure in CRM (cross-check/co-ordinate) 4.10 Poor professional judgments/airmanship 4.11 Disorientation 4.12 Fatigue 4.13 State of mind 4.14 Interaction with automation 4.15 Fast and/or high on approach 4.16 Slow and/or low on approach 4.17 Loading incorrect 4.18 Flight handling 4.19 Lack of qualification/training/experience 4.20 Incapacitation/medical or other factors reducing crew performance 4.21 Failure in look-out 4.22 Deliberate non-adherence to procedures	
A.5 Engine	5.1 Engine failure 5.2 Propeller failure 5.3 Damage due to non-containment 5.4 Fuel contamination 5.5 Engine failure simulated	
A.6 Fire	6.1 Engine fire or overheat 6.2 Fire due to aircraft systems 6.3 Fire - other cause 6.4 Post crash fire	
A.7 Maintenance/ ground handling	7.1 Failure to complete due maintenance 7.2 Maintenance or repair error/oversight/inadequacy 7.3 Ground staff struck by aircraft 7.4 Loading error 7.5 SUPS - Suspected Unapproved Parts 7.6 Unapproved Parts	

Group	Factor	No. acc.
A. *Causal factors*		
A.8 Structure	8.1 Corrosion/fatigue 8.2 Overload failure 8.3 Flutter	
A.9 Infrastructure	9.1 Incorrect, inadequate or misleading information to crew 9.2 Inadequate airport support	
A.10 Design	10.1 Design shortcomings 10.2 Unapproved modification 10.3 Manufacturing defect	
A.11 Performance	11.1 Unable to maintain speed/height 11.2 Aircraft becomes uncontrollable	
A.12 Other	12.1 Caused by other aircraft 12.2 Non-adherence to cabin safety procedures	

B. *Circumstantial factors*

B.1 Aircraft systems	1.1 Non-fitment of presently available safety equipment (GPWS, TCAS, windshear warning, etc.) 1.2 Failure/inadequacy of safety equipment	
B.2 ATC/ground aids	2.1 Lack of ATC 2.2 Lack of ground aids	
B.3 Environmental	3.1 Poor visibility 3.2 Other weather 3.3 Runaway condition (ice, slippery, standing water, etc.)	
B.4 Training	4.1 Training inadequate 4.2 Presented with situation beyond training 4.3 Failure in CRM (cross-check/co-ordinate)	
B.5 Infrastructure	5.1 Incorrect/inadequate procedures 5.2 Company management failure 5.3 Inadequate regulation 5.4 Inadequate regulatory oversight	

C. *Consequences*

C.1 Controlled flight Into Terrain (CFIT) C.2 Collision with terrain/water/obstacle C.3 Mid-air collision C.4 Ground collision with other aircraft C.5 Ground collision with object/obstacle C.6 Loss of control in flight C.7 Fuel exhaustion C.8 Overrun C.9 Undershoot C.10 Structural failure C.11 Post crash fire C.12 Fire/smoke during operation C.13 Emergency evacuation difficulties C.14 Forced landing - land or water C.15 Other cause of fatality	

D. *Unknown*

Level of confidence ______ *High* ______ *Medium* ______ *Low* ______*Insufficient Information*

Note: Acts of terrorism and sabotage, test and military-type operations, and fatalities to third parties not caused by the aircraft or its operation are excluded.

TABLE 2: ASPECTS THAT CAN ADVERSELY AFFECT SAFETY

Design	Manufacturing	Maintenance
New Technology	Technological Obsolescence	Human Factors
Repair	Unwitting Exceedances	Configuration Management
Flight Operations	Air Traffic Control	Adverse Environment
Software	Training	Records
Regulations	Environmental Rules	Unapproved Parts
Hazardous Cargo/Stores		

Figure 1.

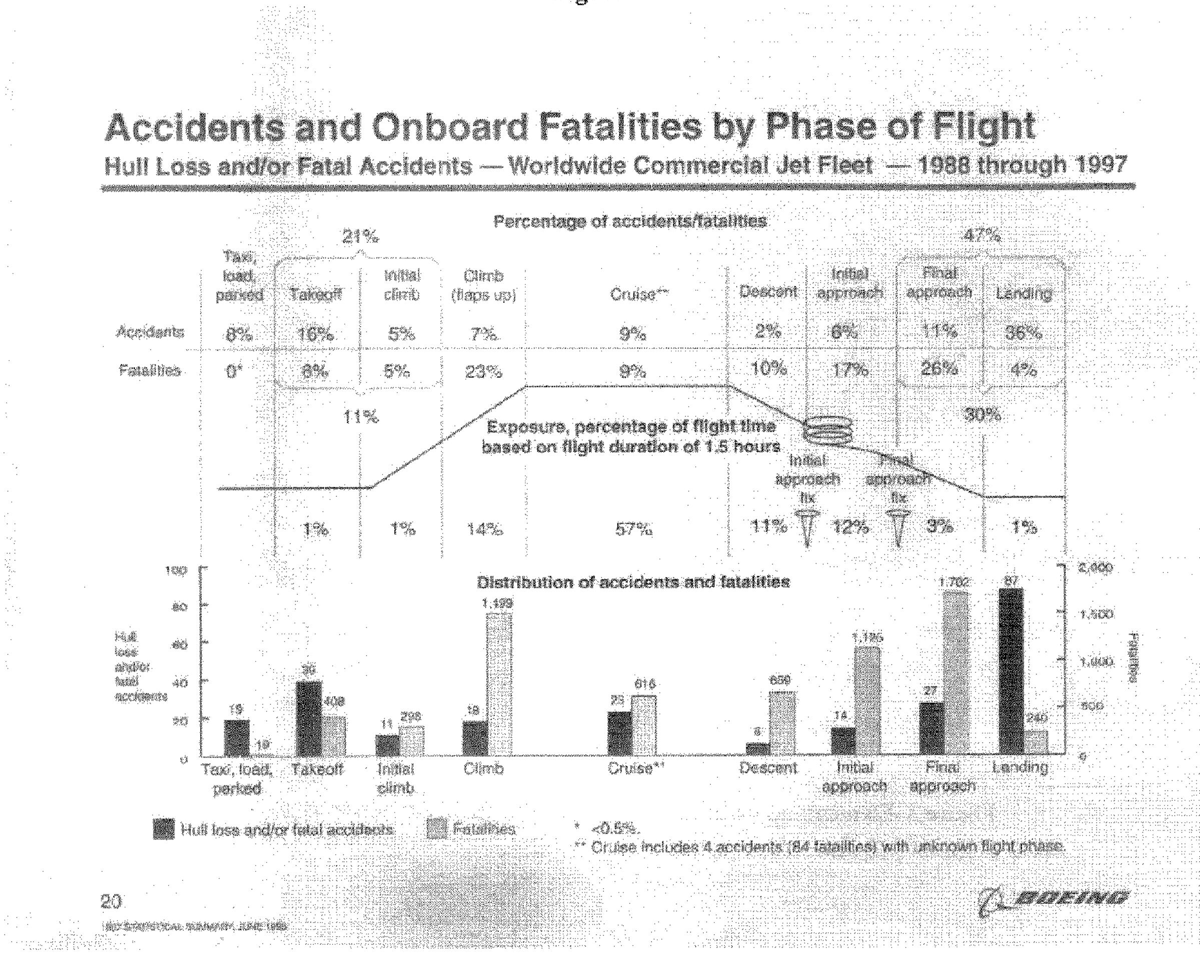

Figure 2.

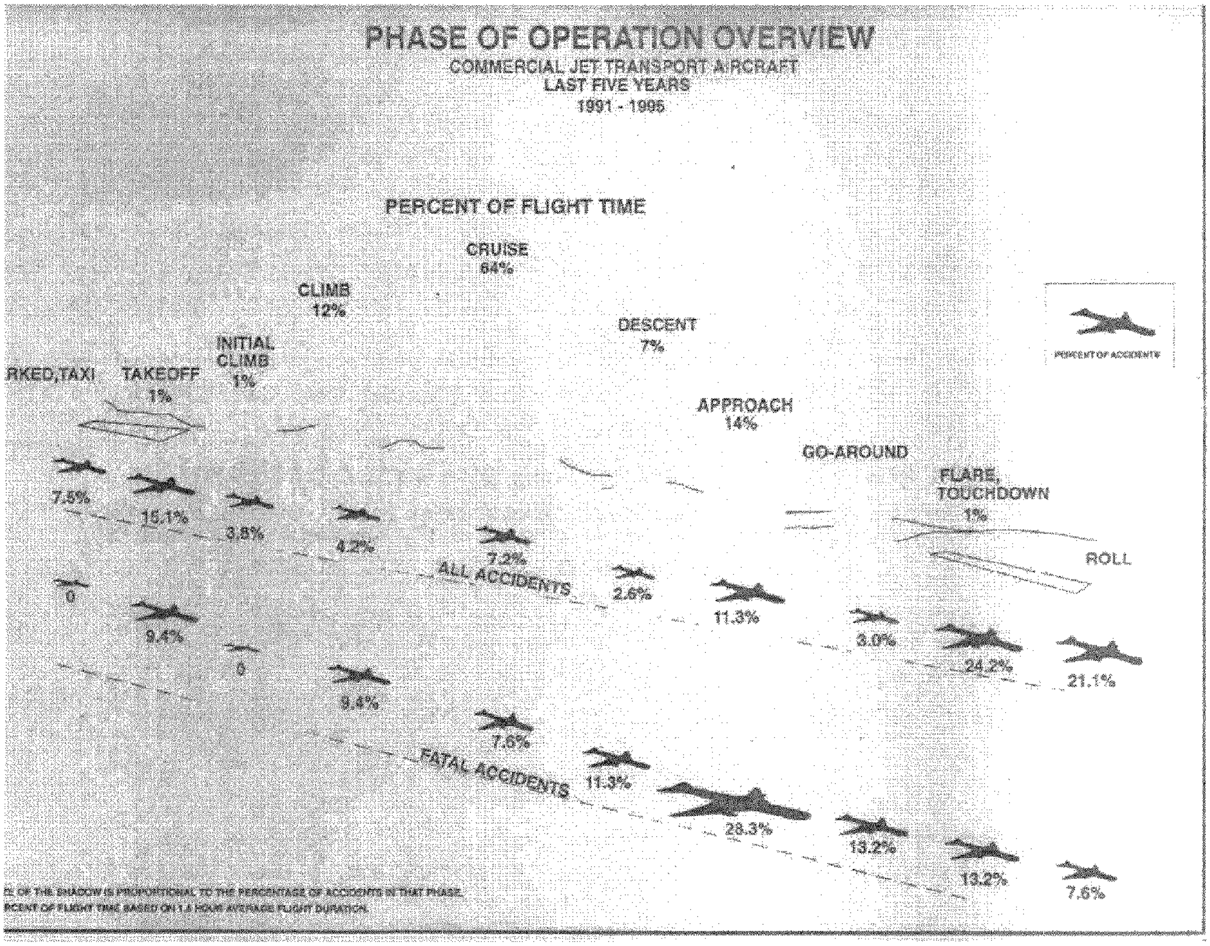

Figure 3. Elements Associated With Service Difficulty Related Activities

Define Requirements ↘ **Collect Data** ↓ **Store & Retrieve Data** ↙ **Ensure Data Quality Standards** ↖ **Analyze Data** ↑ **Validate Requirements** ↗ **Define Requirements**